memorandum

Date: October 11, 2011

To: Jeremy Freimund, Lummi Water Resources Manager

From: Jim Johannessen, LEG, MS, and Jonathan Waggoner, BS

Re: **Sandy Point: South Cape Historical Shore Change Analysis**

Introduction and Purpose

Coastal Geologic Services Inc. (CGS) has performed coastal processes analysis and shore change work at Sandy Point for the Lummi Nation during several different periods since 1995. Earlier work included coastal processes assessments and work at specific properties. Erosion rate determinations were based on air photo analysis and geomorphic evidence in some previous work. The current mapping and erosion rate work is based on new and pre-existing topographic data and analysis, which included numerous years of high quality, direct measurements. This memo is largely an update of previous work by CGS.

South Cape is the narrow, east-west oriented peninsula at the southern end of the larger Sandy Point peninsula. South Cape was created by the artificial dredging of a large entrance channel prior to 1961 (reportedly dredged in 1958) and subsequent dredging and enlargement of the large turning basin in the former uplands at the south end of Sandy Point.

This memo documents new topographic data, and compiles and analyzes the best available topographic data on shore change (erosion/accretion trends) at the Georgia Strait and Lummi Bay shores of South Cape. The Lummi Natural Resources Department requested the work.

Approach and Data Sources

The most accurate and defensible data for compiling a shore change map and calculating erosion rates is detailed (small scale) historic maps (Moore 2000), when they are available. A very good set of detailed maps was available for southern Sandy Point. Past work incorporated all reliable data into one georeferenced dataset. This was done in an AutoCAD program (methods are detailed below). Then, various beach contours and features could be directly compared from different years. The horizontal distance that any feature moved between mapping dates was then calculated as an erosion or accretion rate for the period.

South Sandy Point topographic maps were collected from a variety of sources, including Coastal Geologic Services files, public documents, and Lummi Nation files (Table 1). The oldest detailed map with a scale of less than or equal to 1 inch = 200 ft was from 1962 (McElmon 1962). The map did not contain documentation, but appeared to be quite detailed. The accuracy of this map is not known. A 1982 map (US Army Corps of Engineers 1983) was created through photogrammetry (with surveyed control points) and fathometer measurements. The portions of the map that were used in this analysis were the data collected through photogrammetry. The 1996 map was produced by Walker and Associates Inc (1996), based on aerial photos dated January 11, 1996, along with survey work by Pacific Survey and Engineering Inc (PSE). This map was created through photogrammetry using well-documented methods. Data for the 1997 and 2002 maps were collected by PSE utilizing a total station and direct rod measurements to the beach and nearshore bottom by professional surveyors (PSE 1997, PSE 2002). Data for the 2001 and 2005 South Cape maps were collected by Coastal Geologic Services using high quality survey equipment and direct rod measurements based on survey control established by PSE. The 1996, 1997, 2001, 2002, and 2005 maps met National Map Accuracy Standards for a scale of 1”=100’.

Table 1. Data used for shore change analysis

Year	Source	Data format	Collection method	Coverage	Data Utilized
1962	McElmon	Paper map	Photogrammetry?	N & S Cape	Contours +5’ to +14’ MLLW, 1’ contour interval from +10’ to +14’ MLLW.
1982	COE	Paper map	Photogrammetry w/ field check and bathymetry spot elevations	N & S Cape	Contours 0’ to +14’ MLLW, 2’ contour interval. Bathymetry spot depths down to –46’ MLLW.
1996	Walker	CAD	Photogrammetry	N & S Cape	Contours +6’ to +19’ MLLW.
2001	CGS	CAD	Ground survey	S Cape	Topo pt data from +1’ to +15’ MLLW. OHWM.
2002	PSE	CAD	Ground survey	S Cape, channel	Contours –11’ to +17’ MLLW, 1’ contour interval. Top of Bank, toe of bank, edge of veg.
2005	CGS	CAD	Ground survey	S Cape	Topo pt data from +5’ to +13’ MLLW. OHWM.
2006	CGS	CAD	Ground survey	S Cape, channel	Topo pt data from +3’ to +13’ MLLW. OHWM
2011	CGS	CAD	Ground survey	S Cape	Topo pt data from +4’ to +13’ MLLW. OHWM

COE = Army Corps of Engineers
CGS = Coastal Geologic Services, Inc.
PSE = Pacific Survey and Engineering, Inc.

Methods

The above data sources were used to quantify erosion/accretion trends along the shoreline of South Cape, Sandy Point (Table 1). All calculations were made within AutoCAD Civil 3D 2011 (AutoCAD). Paper versions of south Sandy Point topographic map from 1962 (McElmon 1962) and 1982 (US Army Corps of Engineers 1983) had previously been scanned and georeferenced to Pacific Survey and Engineering, Inc. control points (PSE 1996). Contours were digitized using the “digitize contour” function. Spot elevations were digitized as points with the corresponding elevations. The contours and points were compiled into representative surfaces, which were used for comparison over time.

PSE produced AutoCAD maps using 1996 Walker and Associates photogrammetry as the base. The 1996, 1997, and 2002 maps were received as digital AutoCAD files directly from the surveyors. The 2001 and 2005 CGS ground surveys were processed and compiled within AutoCAD. Digital contours from the PSE and Walker and Associates map products were used to build surfaces for comparison within AutoCAD. All maps were qualitatively checked for accuracy, omitting changes that were due to inaccurate surface comparison, i.e.: those areas beyond or immediately adjacent to the limits of one maps coverage area. In some cases features were not represented each year.

A set of 3 transects were created normal to the shore for erosion/accretion rate calculations. The distances between like contours from different years were measured using the “measure” tool within AutoCAD from various years. The contours/features used were the +8 ft MLLW elevation contour on the mid-beach, and the +12.5 ft MLLW contour at the very upper beach and bank toe. The distances then were imported into an Excel spreadsheet where the short-term and long-term rates were calculated by dividing the horizontal distance of change by the number of years between measurements. The short-term and long-term shore change rates were calculated from the measured distances. For long-term rates, three periods were used: an early period of 1962–1996 using mostly paper maps, a later period of 1996–2011 using mostly ground surveys of higher accuracy, and the entire period of record.

Results

The upper beachface of South Cape at Sandy Point appeared more stable in the western portion of the survey area, near Transect B (Sheet 1, Photo Page 1). Vegetation was seen growing approximately 20 ft waterward of the low bank/erosional scarp at the edge of the "uplands" throughout much of the survey area in September 2011. Toward the middle and eastern end of the survey area, dunegrass (*Elymus mollis*), Pacific gumweed (*Grindelia integrafolia*), and other herbaceous plants had become established waterward of the historically erosional scarp, and may provide some stability to the beach and bank during storm events. The 2006 surveying followed several high-energy wind storms that occurred at very high water levels. However, note that the 2011 photos were taken at the end of summer and the 2006 photos were from early summer. Surface sediments were generally cobbly pebble near the bank toe trending toward pebbly cobble at the mid and lower beachface. At the eastern end of the survey area a 10–15 ft wide band of pebbly sand was seen near MHHW.

Erosion and accretion observations for the three transects at South Cape showed two different general trends. Transects B and C, at the western and middle portions of the study area respectively, have steadily eroded since 1962. Total recession between 1962 and 2011 was 45.3 ft and 40.2 ft at +8 ft MLLW for Transects B and C, respectively (Table 2a). Transect D however, has generally remained stable to slightly accretional until 2011 when the shoreline eroded 11.2 ft at +8 ft MLLW relative to the 1962 position. This reversal is also apparent in ground photos taken during the 2006 and 2011 site surveys (Photo Page 1).

Short-term shore change rates at +8 ft MLLW were highly variable throughout the 1962 to 2011 period of record (Table 2b). The long-term record is a better indicator of trends at the beach. Transect B in particular had a long-term change rate of -0.9 ft/yr for all three periods examined, indicating that this is a good long-term rate for the western portion of the study area (Table 2c). Transect C, halfway between the point on the west and groins on the east, was more variable, but exhibited erosion throughout the period of record. Near the groins, at Transect D, the long-term shore change rate is influenced by recent recession of the beach. The early trend there was for stability, but has shifted to moderately erosional since 1996.

Table 2a–c. Total shore change of South Cape at Sandy Point in feet using maps in AutoCAD (1962-2011). Change measured relative to 1962 location for +8.0 ft MLLW.

a. +8.0 ft MLLW. Total change relative to the 1962 location of +8 ft MLLW.

Transect	1962	1982	1996	2001	2002	2005	2006	2011
B	0.0	-26.2	-31.5	-43.7	-43.6	-46.8	-42.6	-45.3
C	0.0	-6.7	-14.4		-35.7	-37.2	-26.1	-40.2
D	0.0	0.0	4.3		2.8	2.0	4.7	-11.2

b. +8.0 ft MLLW. Rate of change relative to previous data point.

Transect	1962	1982	1996	2001	2002	2005	2006	2011
B		-1.3	-0.4	-2.4	0.0	-1.1	4.1	-0.5
C		-0.3	-0.6		-3.5	-0.5	11.1	-2.8
D		0.0	0.3		-0.2	-0.3	2.7	-3.2

a. +8.0 ft MLLW. Rate of change for periods shown.

Transect	1962-1996	1996-2011	1962-2011
B	-0.9	-0.9	-0.9
C	-0.4	-1.7	-0.8
D	0.1	-1.0	-0.2

Data for the +12.5 ft MLLW contour was not available for the 2001 and 2005 survey data, as the survey did not extend to this elevation. As with the +8.0 ft MLLW data, recession has been the general trend at Transects B and C, with 53.9 ft and 54.3 ft of recession respectively. Transect D has eroded since 1962, and in 2011 was 8.8 ft landward if its 1962 position. Short-term rates were as variable at +12.5 ft MLLW as they were at +8.0 ft MLLW, with recession rates of between 0.0 ft/yr and 1.7 ft/yr at Transects B and C, and 2.7 ft/yr for Transect D (Table 3b). The long-term trend for both Transects B and C was recession of 1.1 ft/yr since 1962. Transect D, near the groin, has remained more stable, but has also been erosional, due to the protective influence of the structure.

Table 3a–c. Shore change of South Cape at Sandy Point using maps in AutoCAD, 1962–2011.

a. +12.5 ft MLLW. Total change relative to the 1962 location of +8 ft MLLW.

Transect	1962	1982	1996	2002	2006	2011
B		-21.8	-37.6	-45.9	-53.7	-53.9
C		-16.9	-24.9	-39.3	-45.6	-54.3
D			3.8	6.5	4.5	-8.8

b. +12.5 ft MLLW. Rate of change relative to previous data point.

Transect	1962	1982	1996	2002	2006	2011
B		-1.1	-1.1	-1.4	-2.0	0.0
C		-0.8	-0.6	-2.4	-1.6	-1.7
D			0.1	0.5	-0.5	-2.7

c. +12.5 ft MLLW. Rate of change for periods shown.

Transect	1962-1996	1996-2011	1962-2011
B	-1.1	-1.1	-1.1
C	-0.7	-2.0	-1.1
D	0.1	-0.8	-0.2

Conclusions

The entire upland area of South Cape appears to have been filled at least two times: once soon after 1962, and again in the late 1960's. This is evidenced by comparison of the 1962 +8 and +12.5 ft MLLW contours with the corresponding 1982 contours, as well as examination of the original maps and historic aerial photos (Johannessen 2002). Erosion rates at the south shore of South Cape were therefore artificially low during the 1962 to 1982 period. After 1982, the area of the most change (erosion) was the southern shore of South Cape (Johannessen 2002). An erosion scarp has been visible at the intersection of the beach and the filled "uplands" at South Cape most years (Sheets 1 and 4, Photo Page 1).

Results from 1996 to 2011 are considered the most accurate of all data presented in this memo and best reflect current trends. The +8 ft MLLW elevation contour reflects upper beach changes that are most applicable for upper beach trends at the South Cape area. Erosion was the trend from 1996 to 2011, measured from the +8 ft MLLW elevation contour. Transect C experienced the highest erosion rate, averaging 1.7 ft/yr, from 1996 to 2011 (Table 2c). Transect B experienced 0.9 ft/yr of erosion, which matched the 1962–2011 rate for that Transect, and was very similar to the 0.8 ft/yr of erosion at Transect C for the longer period. Similar results were seen for +12.5 ft MLLW, with Transect C experiencing more erosion in the 1996–2011 period (1.9 ft/yr of erosion; Table 3c), but having the same rate for the 1962–2011 period as Transect B (1.1 ft/yr of erosion).

The erosion rates calculated for this site can be compared to the total width of the uplands, which for Transects B and C was approximately 150 ft in 2011. Using the 1996–2011 erosion rate of 1.7 ft/yr from Transect C, the entire 150 ft of uplands would erode in 88 years. If current trends continue, which appears likely in the absence of significant alteration of the geometry of Sandy Point, South Cape would likely disappear by the end of the century.

Transect D, near the groin field, has very likely been influenced by the presence of the low concrete groins fields across the beach. The recent trends here have been for moderate erosion. However, this may be an aberration in the data, and the beach may accrete back to near the level of the concrete groin in the future.

Erosion rates calculated in this study were relatively rapid for the Puget Sound and Georgia Strait area, where typical erosion rates at eroding shorelines are typically around 0.3 ft/yr and very rarely exceeded 1.0 ft/yr over the long term (Keuler 1988, Canning and Shipman 1994). Long term erosion rates measured at a vaguely similar setting, at southwest Pt. Roberts, were between 2.2 and 2.6 ft/year (Johannessen 1998). The Point Roberts site was also negatively impacted by up-drift development of the Tsawwassen ferry terminal causeway, which traps the historic southward net shore drift, as well as potential interruption of littoral drift caused by the Point Roberts Marina channel and groins (Johannessen 1998).

It must be noted that measured cumulative erosion at South Cape would have been substantially higher if large volumes of fill were not added (without permits) to the tidelands and uplands soon after 1962, again between 1966 and 1970, and possibly at other times (Johannessen 2002). Additionally, predicted future sea level rise and storminess in the Pacific Northwest are likely to lead to increases in the actual erosion rate at Sandy Point (Cayen et al. 2009, Rahmstorf et al. 2007, Snover et al. 2005, Pethick 2001). Therefore, the 88 year time-frame given above may prove to be a gross underestimate of the amount of time remaining before this portion of South Cape erodes completely.

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ATTACHMENTS:

Photo Page 1. Ground photographs taken 7/7/06 and 9/8/11

Sheet 1. South Cape, Sandy Point Beach Topography

Sheet 2. South Cape, Sandy Point +8 ft MLLW

Sheet 3. South Cape, Sandy Point +12.5 ft MLLW

Sheet 4. South Cape, Sandy Point Cross Sections


7/7/06 – Concrete groin barely visible above grade


9/8/11 – concrete groin exposed approximately 6" above grade

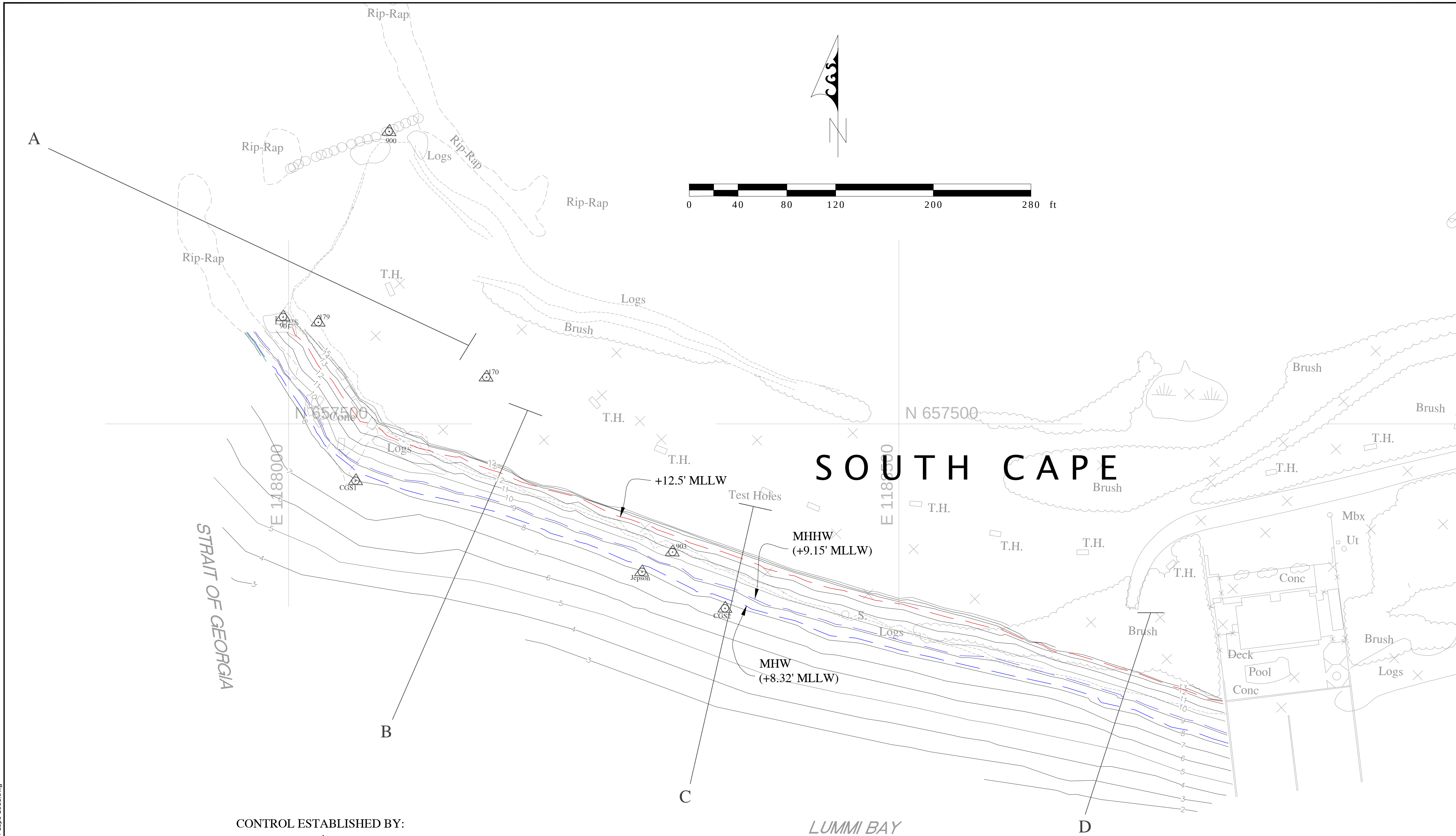

7/7/06 – Rock revetment and concrete debris at west end


9/8/11 – Same rock revetment and concrete


7/7/06 – western area looking east


9/8/11 – same area showing vegetation

Photo Page 1. Ground photos of the South Cape Sandy Point beach showing conditions from the 2006 and 2011 surveys.



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DESIGNED BY:
CHECKED BY: JWJ
DATE SURVEYED:
9/8/11

South Cape Sandy Point
2011 Beach Topography

Lummi Indian Business Council

MLLW=0.0'

SCALE: AS NOTED
DATE:
10/10/11
SHEET:
1
OF: 4

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DATE: 12/19/02

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HORZ. DATUM= NAD83/91 VERT. DATUM= MLLW

PSE SURVEY CONTROL TABLE

PNT NO.	NORTHING	EASTING	ELEV.
170	657538.1034	1188162.0960	16.25
179	657583.1938	1188024.3476	15.13
180	657534.2550	1189333.4800	12.90
900	657739.3600	1188082.4235	15.04
901	657587.4673	1187995.5537	14.11
903	657394.9709	1188314.5357	11.69

HORZ. DATUM= NAD83/91 VERT. DATUM= MLLW

CGS SURVEY CONTROL TABLE

PNT NO.	NORTHING	EASTING	ELEV.
CGS1	657453.264	1188055.047	7.08
CGS2	657348.724	1188357.645	8.12
Jepson*	657378.535	1188289.567	8.41

* Found rebar, not placed by CGS

Horizontal datum is NAD83 State Plane North, vertical datum is MLLW.
Background data in grey from Walkerand Associates photogrammetry.

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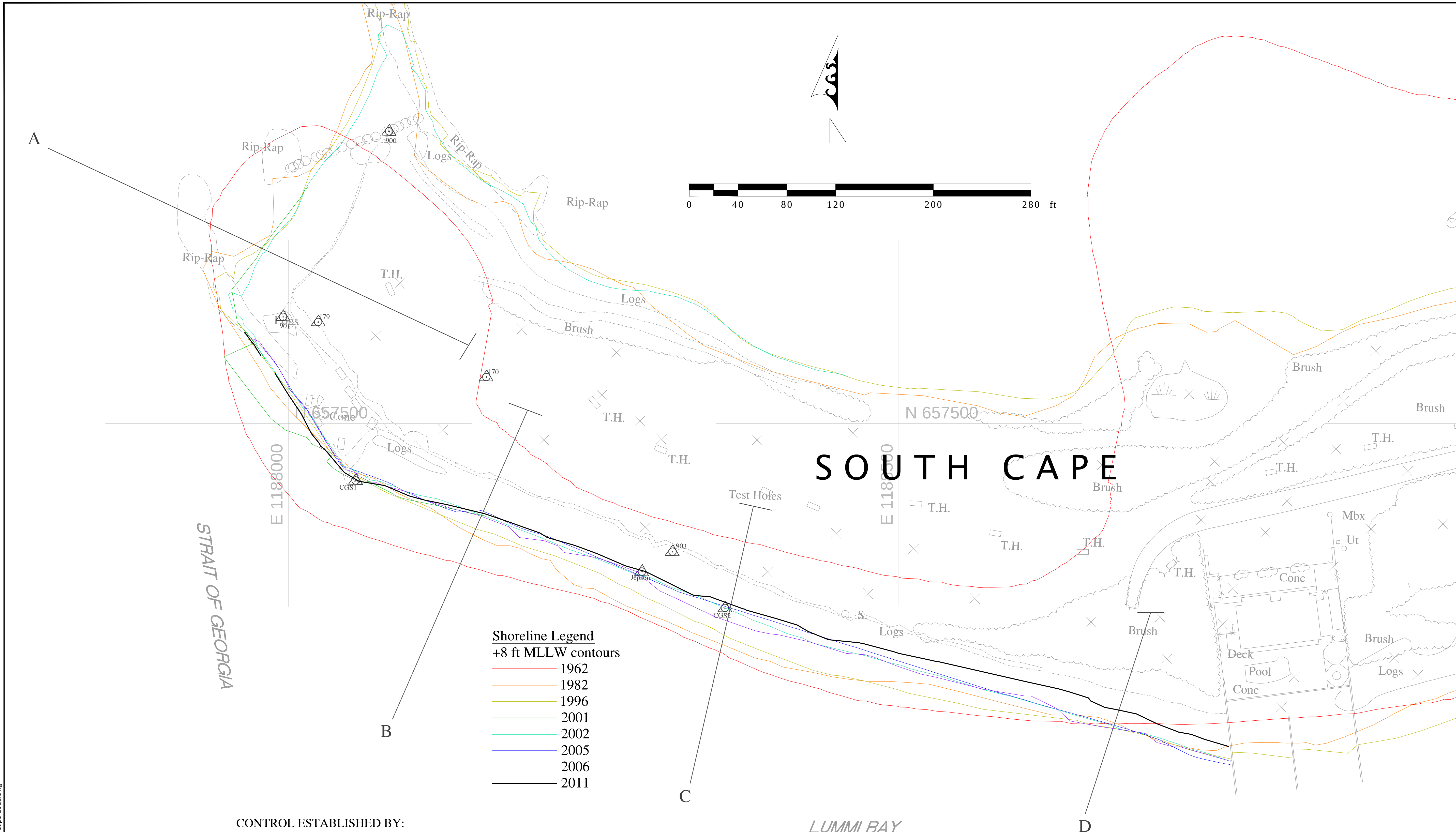

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DRAWN BY: JFW
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DATE SURVEYED:
9/8/11

South Cape Sandy Point
+8 ft MLLW contour

Lummi Indian Business Council

MLLW=0.0'

SCALE: AS NOTED
DATE:
10/10/11
SHEET:
2
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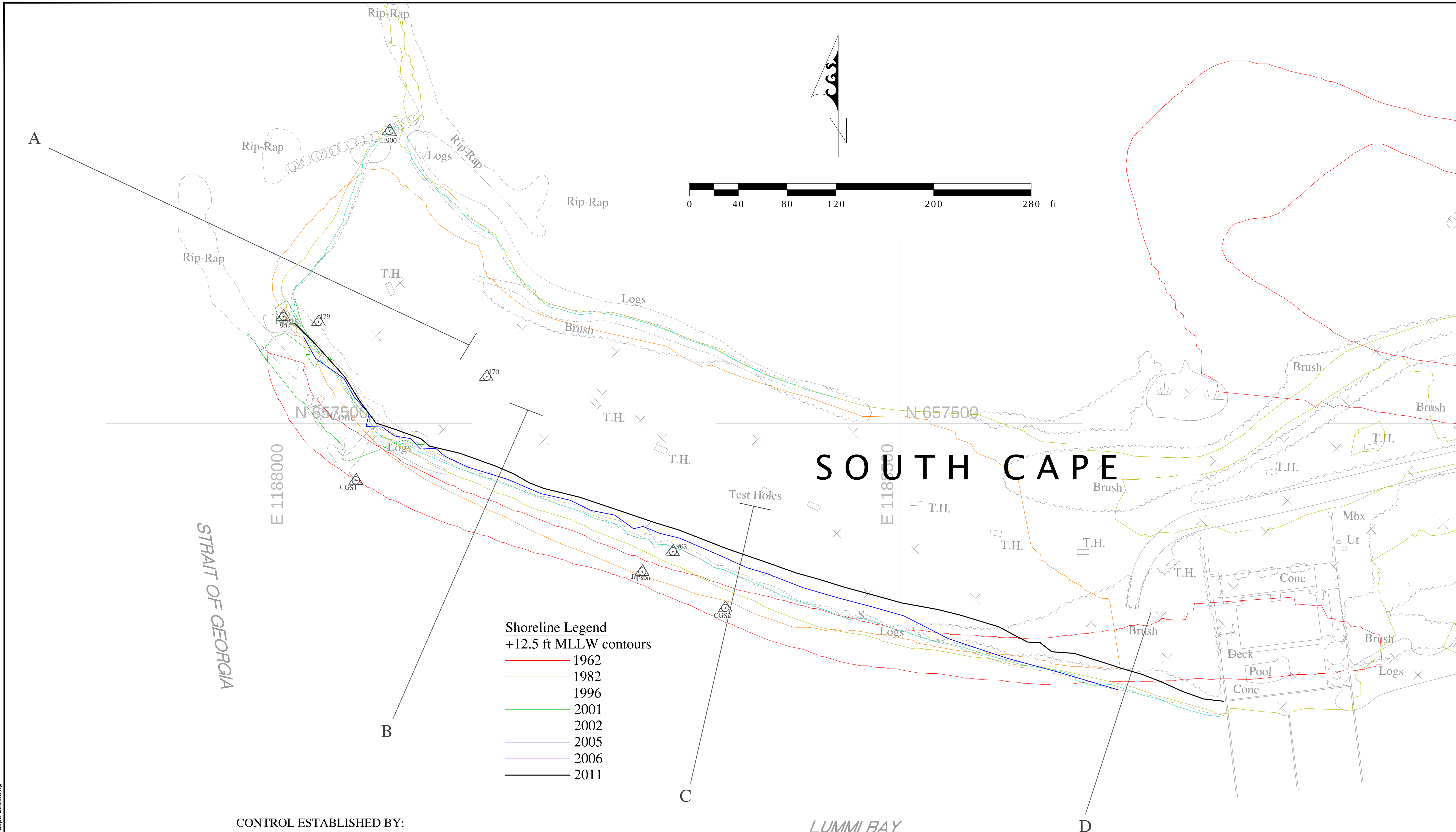

South Cape Sandy Point

+12.5 ft MLLW contour

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MLLW=0.0'

SCALE: AS NOTED
DATE: 10/10/11
SHEET: 3
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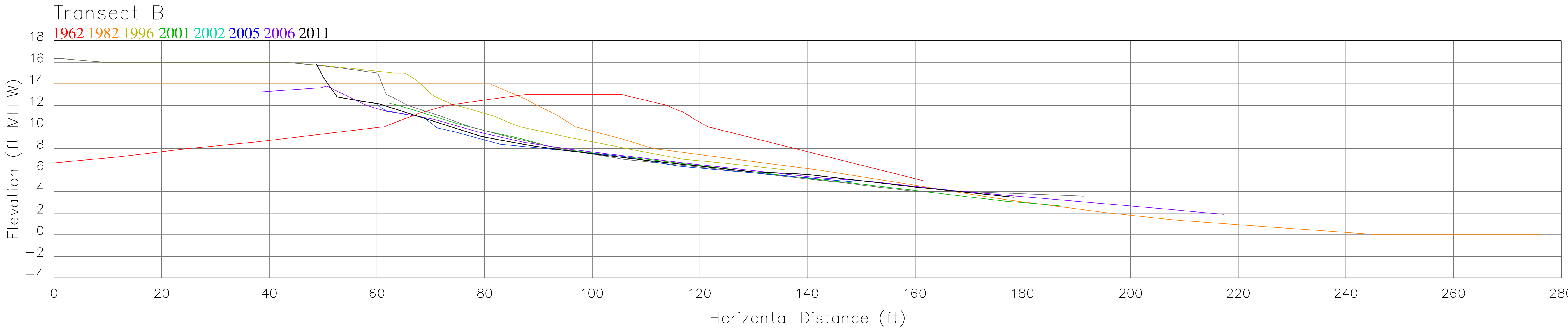

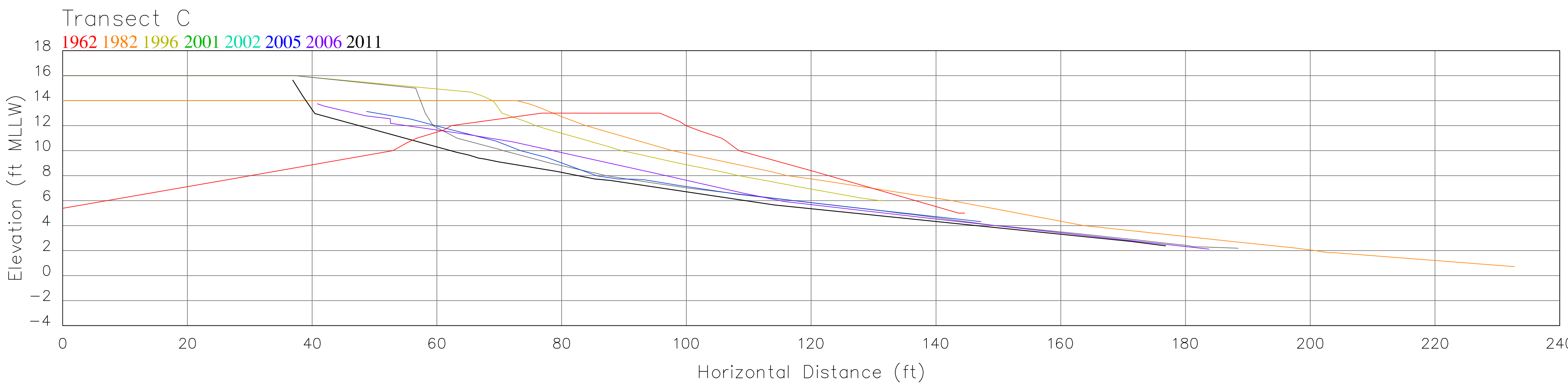

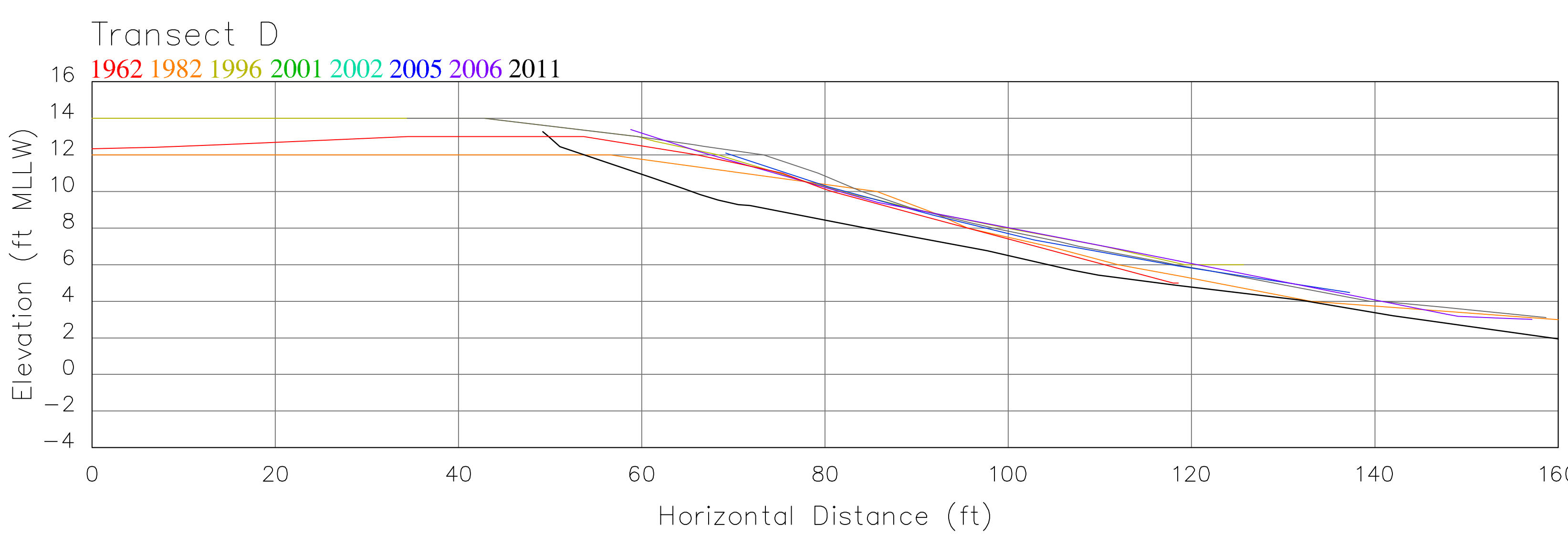

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South Cape Sandy Point
Cross Sections

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MLLW=0.0'

SCALE: AS NOTED (2x vert. exag.)

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